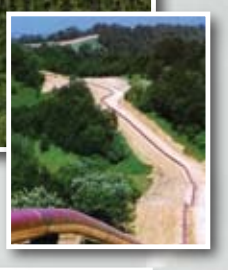
The RoW Surveillance Challenge



Third-party strikes to the nation's liquid and gas pipeline infrastructure are the leading cause of damage and spills. These strikes pose significant hazards to the general public and the environment as well as disruption of the supply chain.

Monitoring pipelines and pipeline rights-of-way (RoW) is more important than ever

- Risk of terrorist attack on critical national infrastructure
- A catastrophic event could jeopardize the public and the environment
- Detection of ground disturbances, equipment/spills under the tree canopy, and crude oil leaks below snow cover
- $$$ Millions spent to repair damage
- Reputation of energy industry
- License to Operate

New Technologies for Energy and Transportation Monitoring can provide:

- More Frequent Surveillance
- Earlier Detection
- Enhanced and automated incident detection/alerts
- Video capture and archiving
- Deterrent to threats (unpredictable, random schedule)
- Reduced industry's cost repair damage
- Enhanced RoW Security
- Reduced Risks to Pilot/Public
- Reduced 3rd Party Damage

Supporting NASA Earth Science Goals Through Applied Science and Partnership Development Activities

NASA's Earth Science Mission, ***" …to conduct aeronautical and space activities so as to contribute materially to ...the expansion of human knowledge of the Earth and of phenomena in the atmosphere and space"***, guides NASA's development and infusion of pioneering technologies and systems that:

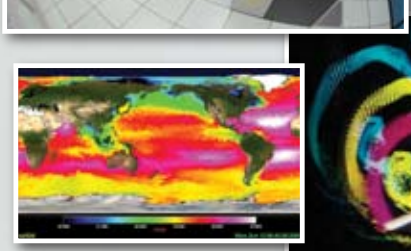
- Observe, understand and model the Earth System;
- Detect how it is changing;
- Better predict change; and
- Understand the consequences of life on Earth.

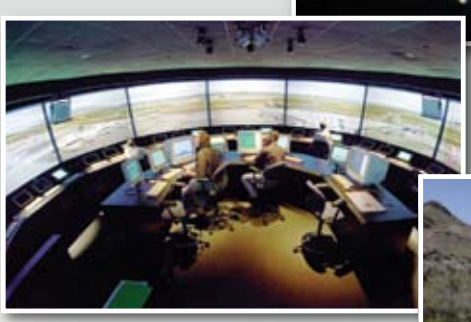
In pursuit of this mission, NASA increasingly relies on other agencies, industry and academia to help bridge critical technology gaps through the transfer and joint development of technology:

- Greater emphasis on the use and application of market-driven technologies (COTS)
- Infusion of technology through strategic collaborations with partners to achieve mission specific goals
- Identification and clarification of research needs following application
- Collaborative development of products serving both commercial markets and NASA's missions

As a Federal research center, NASA Ames also seeks to provide economic and societal benefits to the nation by:

- Expanding and accelerating the use of knowledge, data, and technologies resulting from NASA science research (NASA Applied Science Program)
- Fostering technology partnerships, commercialization and innovation in support of NASA's overall mission and national priorities (NASA Innovative Partnership Program).





An Approach to Improving Pipeline and Earth Monitoring

Currently, no single system, service or technology can be cost effectively applied over the entire pipeline system. An extensive pre-competitive, collaborative effort is required to define the data and process gaps, set priorities, establish the requirements, and drive the early stage development and demonstration of technologies and systems toward commercialization.

Leveraging NASA Ames' Applied Research and Technology Capabilities

The development of solutions for pipeline monitoring can draw from and contribute to efforts currently underway to improve Earth observing systems by:

Selecting, advancing, testing and demonstrating imaging and sensor technologies to enable automatic detection, and overcome adverse monitoring phenomenon such as fog, rain or darkness.

Improving data management, integration and interpretation systems to enable remote capture and processing of information, threat detection, automated alerts, archiving, and human-systems integration.

Improving airborne detection capabilities (manned to unmanned airborne systems (UAS)) to enable safe, cost effective and frequent RoW surveillance and monitoring.

Additionally, a NASA-Pipeline Industry-DOT/PHMSA collaboration can build on NASA Ames' long proven and unique history with the:

- development of remote sensing and airborne systems in conjunction with the commercial sector;
- detailed development of requirements and well coordinated deployment of assets in conjunction with regulatory agencies (FAA, etc.); and
- experience and expertise in bridging the needs and capabilities of the private and public sectors, pushing further technological development while defining and addressing project specific issues in a manner consistent with regulatory requirements.

NASA Ames Research Center's Core Capabilities include:

Basic Research - Ames researchers study the fundamental physics and chemistry of planetary atmospheres and ecosystems from the air and space. Active, passive, and in situ observations are used to improve current models of atmospheric and ecosystem evolution.

Platform enhancement - Ames partners with other NASA Centers, agencies, universities, and manufacturers to enable improved platform capabilities.

Sensor development - New types of measurements lead to discoveries in the fundamental processes of the earth system. Ames has multiple facilities for in-house fabrication of sensor systems as well as a NIST rated calibration facility.

Intelligent Mission Management - Processes developed for the Mars Rover team are being used to aid in airborne science mission planning and operations, and information visualization, analysis and sharing.

Modeling and Simulation - Ames provides world-class computational facilities (Columbia Supercomputer) to model earth system processes and drive high-speed, complex simulation computing of modeled events.

Engineering and Scientific Workforce - Ames has access to diverse and talented world class technical, engineering and scientific human resources through its network of public and private institutions and organizations, and a 'Can Do' culture.

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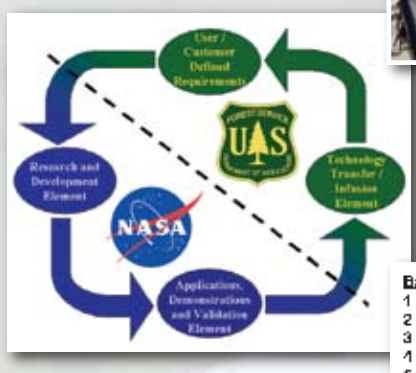
A Model From Wildfire Research and Applications Partnership

A collaboration between NASA and the U.S. Forest Service – the Wildfire Research and Applications Partnership (WRAP) project – developed, matured, evaluated, integrated and transitioned key NASA, university and industry technologies and capabilities to enhance tactical wildfire monitoring, management and observational capabilities.

NASA led technology and process integration efforts resulting in:

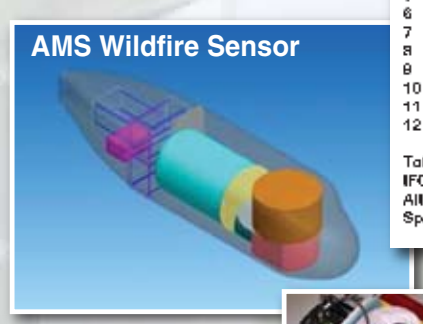
- Enhanced UAS platform utility;
- Development and integration of new requirements-driven sensor technologies;
- Maturing real-time data telemetry and autonomous real-time processing; and
- Innovative data visualization and evaluation capabilities.



Stakeholders from the wildfire management and science community, the Tactical Fire Remote Sensing Advisory Committee (TFRSAC), guide development efforts by detailing data and information gaps, defining priorities for wildfire management capability enhancements, and smoothing the infusion of new technologies and processes into operational practices.

The Western States Fire Mission (WSFM) demonstrated key elements of the WRAP project, showcasing an end-to-end solution-set for providing real-time disaster-related information to Wildfire Incident Management Teams, including:

- The first time integration of a large UAS into the National Airspace for long-endurance/range data gathering;
- The development and transfer of a disaster-specific imaging sensor, tailored to improved wildfire observations;
- The development and demonstration of a data management decision support system derived from a NASA Exploration Program software capability, enhanced using a COTS visualization package for ease-of-use by disaster teams, and;
- The development and integration of software technologies for on-board autonomous processing of sensor-derived imagery and real-time telemetry of such to disaster decision makers.

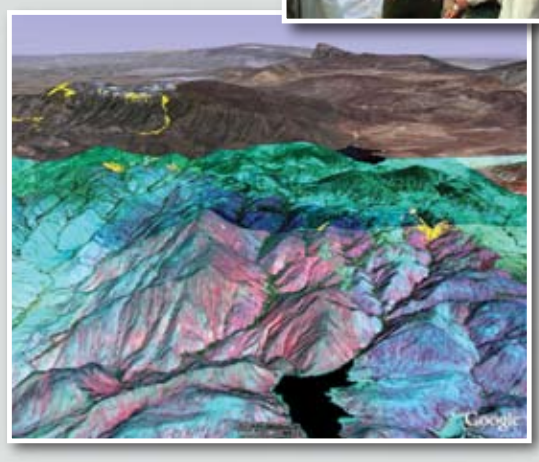


Band	Wavelength µm
1	0.42-0.45
2	0.45-0.52 (TM1)
3	0.62-0.80 (TM2)
4	0.60-0.62
5	0.63-0.69 (TM3)
6	0.69-0.75
7	0.76-0.90 (TM4)
8	0.91-1.05
9	1.55-1.75 (TM5)
10	2.08-2.35 (TM7)
11	3.60-3.79 (VIIRS M12)
12	10.26-11.26 (VIIRS M15)

Total Field of View: 86.9 degrees
IFOV: 2.5mrad
Altitude: 25000'
Spatial Resolution: 20m (at sea level)

The highlights of the WRAP and WSFM during 2007 include:

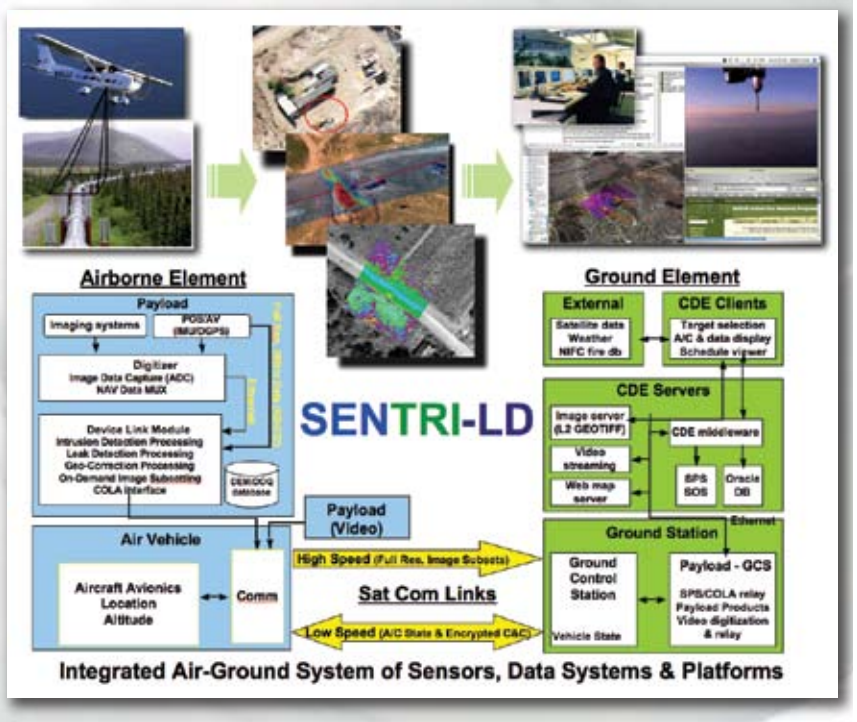
- First-ever flights of a UAV in the NAS over extended regions of the continental western US for disaster support.
- UAS / sensor collections over 60 fire events on eight missions with real-time data delivered to each disaster management team.
- Flew four UAV missions of “emergency support” to the Southern California wildfires of October 2007, integrating seamlessly and flawlessly into the busiest National Airspace (NAS) in the country.
- Provided real-time data to eleven (11) ICC teams on the major SoCA wildfires, as well as to three county-level Emergency Operations centers (EOC)(San Diego, Orange, Riverside counties).
- During the eight missions, the provision of real-time data to ICCs saved million of dollars in personnel time, fire-fighting costs, property, and natural resource loss.
- Demonstrated robustness of UAV, sensor, and processing system during eight missions of 8-21 hours duration with over 2,000 data sets collected and delivered with no data loss or system failures.
- Capabilities demonstrated are in adaptation by partners for operational utility.



Improving Surveillance – Project Concept and 2007 Preliminary Tests

NASA Ames Research Center and BP Pipelines and Logistics North America conducted a preliminary exploration and testing/demonstration project in 2007 that:

- *Conceptualized a longer-term effort to more efficiently monitor pipeline rights-of-way and improve the detection of intrusions and leaks;*
- *Tested/demonstrated potential methane detection and camera-based surveillance systems.*



The SENTRI-LD Concept

A concept project, dubbed "SENTRI-LD", calls for the development and demonstration of the systems and operational processes for remotely detecting intrusions into pipeline rights-of-way and leaks from liquid/gas pipelines via sensors and imaging systems on small manned and unmanned aircraft.

Preliminary Testing/Demonstration Projects

Methane and Oil Spill Detection Project

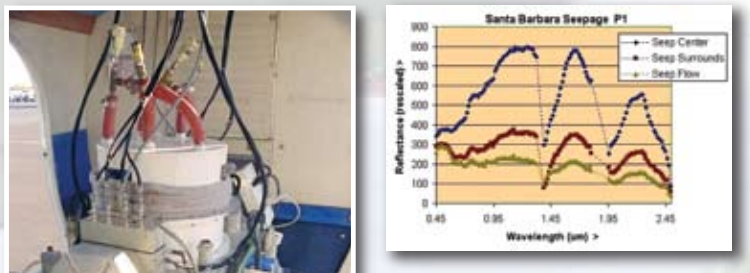
UC Santa Cruz

Focus

- Direct Detection of CH4 gas above snow and ice
- Direct detection of organic liquids on snow and ice
- Direct detection of CH4 gas above water
- Direct Detection of organic fluid spill on land using Hyperspectral RMOTC 2004 imagery
- Direct Detection of CH4 gas using Hyperspectral RMOTC 2004 imagery
- Detection of plant stress induced by underground CH4 leaks using Hyperspectral RMOTC 2004 imagery
- Habitat mapping for baseline and change detection using Hyperspectral RMOTC 2004 imagery

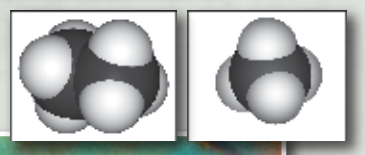
Current status:

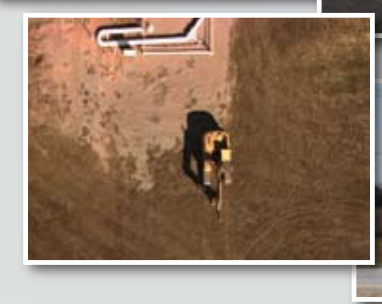
Preliminary phase complete, Report available



Oil seep on water – CA

Oil spill on snow – AK





Intrusion Detection Camera Evaluation Study

NASA and BP teamed to evaluate performance of several camera systems for suitability for automated intrution detection in realistic environment:

- To provide a basis for determining if Mercury Computer Systems' (MCS) cameras can provide images that allow a ground-based human operator to identify threats.
- To provide a basis for determining if MCS cameras can provide images of acceptable quality for the ROW archival video record.
- To assess performance of MCS anomaly detection software, vs. requirements.
- To provide a basis for determining if NASA-provided cameras can provide images that allow a ground-based human operator to identify threats.
- To provide a basis for determining if NASA-provided cameras can provide images of acceptable quality for the RoW archival video record.
- To provide a basis for determining acceptable spatial resolution for ROW monitoring by a human image interpreter.
- To collect imagery to support development of NASA detection algorithms.

Current Status:

Field test phase complete

Preliminary summary complete

BP evaluation in progress

NASA post-test rpt in progress